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Analysis of electromagnetic waves propagation on rough surface

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Abstract
The main purpose of this paper is to simulation of electromagnetic wave propagation. An original method, for a better taking into account of the surface's roughness, was introduced. This method is based on generation of surfaces and the use of a roughness parameter to model small roughness. The results presented show an amelioration of propagation loss computation, the effects of the surface's roughness are more perceptible in the results obtained with the new method.

Keywords: Analysis, electromagnetic, propagation, rough, surface

Introductions

When electromagnetic radiation and scattering problems are posed in terms of integral equations, it is common for some form of the electric-field integral equation to be employed. Numerous methods are able to predict the electromagnetic wave propagation in the troposphere. Mainly two methods are developed in literature, exacts methods (Mode theory) [1] and asymptotic methods (geometrical optic, parabolic equation) [2, 3, 4], the most popular method is the parabolic equation. In this paper a model based on this equation has been implemented to provide a tool for electromagnetic wave propagation prediction above rough surfaces. A new method, based on surface generation, is introduced for better taking into account of the surface's roughness.

Formulation

A numerical solution of the problem of scattering by either open or closed arbitrarily shaped conducting bodies is presented. Here we are interested on electromagnetic wave propagation in the troposphere, the lowest layer of Earth's atmosphere. The mean average depth of the troposphere is parameter in the electromagnetic wave propagation in the troposphere. It can be calculated using Smith-Weintraub model [5]: $n = 1+7.76.10^{-5}\,P/T + 0.373\,e/T^2$, where P is the atmospheric pressure, T is the temperature in Kelvin and e is the partial pressure of vapour.

To calculate the scattering properties for different kinds of surfaces, the understanding of the their dielectric proprieties is essential. These proprieties are function of complex permittivity ε' - j ε - j where ε' represents electrical propagation capacity and ε' represents electrical loss. For maritime surface, we use Debye model [6] to calculate ε' as a function of temperature T, salinity S of the surface and frequency of incident wave in X-band for a temperature between 0^0 C and 40^0 C and salinity rate between 4 ppt and 35 ppt as shown in fig.-1.

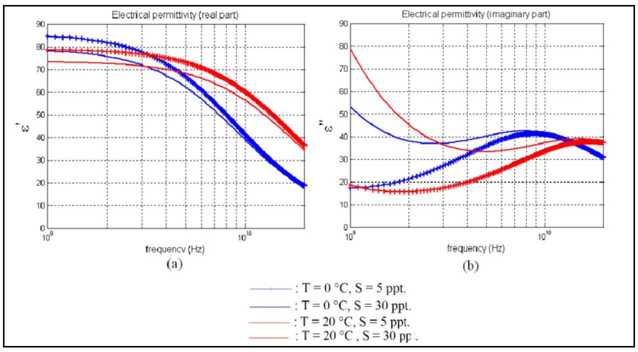

Fig 1: Debye model (a) Real part of permittivity (b) imaginary part of permittivity

In the case of snowy surface, we use Ozawa *a* Kuroiwa' model [7]. The complexity of terrestrial surface impose the use of semi-empirical models like Topp model [8] or Dobson-Peplinsky model [9]. Topp quantifies permittivity of the ground in function of humidity rate for low frequency (20 MHz-1 GHz) as shown in Fig.-2. For higher frequencies, we use Dobson- Peplinsky model.

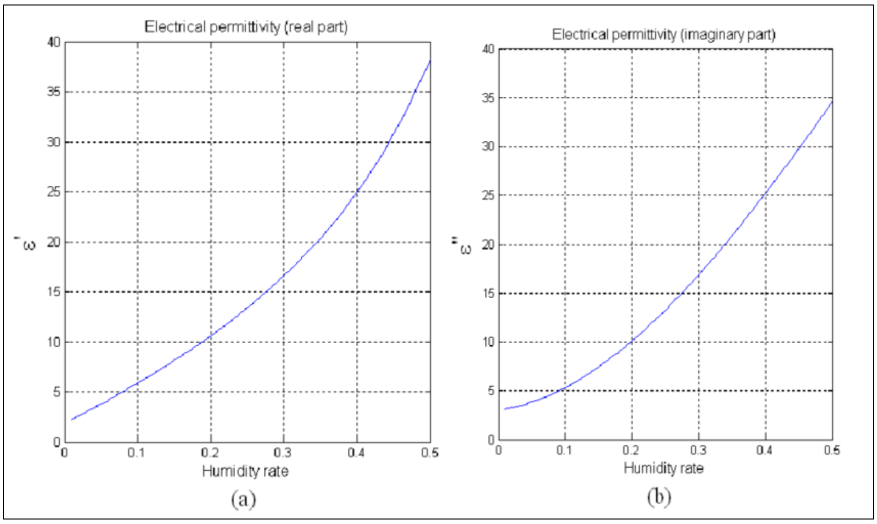

Fig 2: Topp model (a) Real part of permittivity, (b) Imaginary part of permittivity

Accurate modeling of electromagnetic wave propagation over irregular terrain is crucial for the prediction of radar performance. To observe the influence of this type of terrain, we introduce a new method which consists on generating surface using a spectrum. Once the surface created, the electromagnetic wave is propagated using the method introduced by Mac Arthur and Bebbing ton [10]. In literature, we find a method which consists on an introduction of a roughness parameter [11, 12]. In our method this parameter is used to model the influence of the low this parameter is used to model the influence of the low roughness that cannot be introduced in surface generation because of mesh limitation.

To generate a sea surface we use Elfouhaily spectrum [13] and a Monte-Carlo simulation [14]. This spectrum given in function of wind's speed and one- dimensional fetch.

Results and Discussion

Numerical results are presented for surface current distributions induced on selected scatters under plane wave illumination. The simulations are used to show the influence of natural surface's geometry and constitution in electromagnetic waves propagation. The results obtained coherent whit those presented by Sevgi [15]. The path loss for a terrestrial surface in UHF- band (500 MHz), the source is placed at 70m height. The classical method consists on introduction of roughness effects using a coefficient. We can see that the new method allows a better a coefficient. We can see that the new method allows a better taking into account of the surface roughness. Indeed, the interference lobes are less extended in the results obtained by the new method. Also, path loss for a sea surface in X-band (10 GHz) a source placed at 30m height and a wind speed of 15m/s. The new method allows a better of the surface's geometry, the perturbations due to roughness are more perceptible.

Conclusion

An evolution of our work will be the implementation of this method in a tridimensional propagation domain in presence of different types of natural surfaces. This generalization will require an adaptation of the propagation equation, the surface generation and roughness parameter.

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